Grid resolution, time discretization, boundary condition, and other challenges in coupled surface/subsurface hydrological modeling

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EGU23-10152
EGU General Assembly 2023

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In this study we push the limits of a physics-based detailed model of surface water/groundwater interactions, CATHY, in order to explore numerical issues related to discretization, coupling, and scale effects. Regardless of the spatial scale of the model domain (field, hillslope, catchment, ...), the processes that are simulated by integrated models such as CATHY are characterized by different dynamic time scales across subsystems and thus require appropriate time stepping schemes. Accurate tracking (in a mass balance sense) of complex exchange fluxes is also a challenge. At larger spatial scales, concerns related to aspect ratio and mesh distortion can influence and constrain grid discretization choices. Across the land surface boundary, different options for representing boundary conditions can lead to widely varying model behaviors. Finally, model performance assessments can be highly sensitive to the response variables of interest. We will illustrate some of these challenges via test case simulations of a long (13 km) transect and a small (0.3 ha) hillslope.